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Control of Biosonar Behavior by the Auditory Cortex

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Lesion experiments were conducted to examine whether the functional organization of the mustached bat's auditory cortex is related to biosonar behavior in the manner inferred from previous neurophysiological experiments. Bats were swung on a pendulum towards a target to elicit echolocation behavior, and their adjustments in their biosonar signals measured: Doppler-shift compensation (to correct for Doppler-shift in echoes), intensity compensation, and rate and duration adjustments. Following bilateral aspiration ablations of the entire auditory cortex, the amount and stability of Doppler-shift compensation was significantly less, and the reaction time for this response significantly greater than preablation. Subsequent localized ablations identified the DSCF area
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Technical Report

The major aim of this project is to examine, by means of critical lesion experiments, whether the functional organization of the mustached bat's auditory cortex is related to biosonar behavior in the manner inferred from previous neurophysiological experiments.

Our first behavioral task involved swinging bats on a 2.8 m long pendulum towards a large target. Before the cortical ablations, these bats showed the behavioral adjustments made during natural flight towards a target: they compensated for the Doppler shift in returning echoes, reduced pulse amplitude, increased pulse rate, and decreased pulse duration. Their Doppler-shift compensation (DSC) was 80% of the amount of Doppler shift, and their reaction time for DSC averaged 96 ms. They also showed memory for the amount of Doppler shift occurring at different parts of the pendulum's arc. Following large bilateral ablations of the auditory cortex (AC) (n=4), the amount of DSC was reduced to an average of 35%, and the reaction time increased to an average of 150 ms. Similar effects were observed when only the DSCF (Doppler shift constant frequency) area of the AC was ablated (n=2): the amount of DSC was reduced to an average of 54%, and the reaction time increased to an average of 211 msec. Similar results have been obtained in one bat in which the DSCF was 'reversibly lesioned' by topical application of muscimol, a GABA agonist, which produces tonic inhibition lasting for several hours. We are currently replicating this effect. For all of these animals, the other behavioral adjustments were unaffected by the ablations. Electrical stimulation of the cingulate cortex (Cg), the highest vocalization center, suggests that it has a motor map for the control of pulse frequency. When the Cg was bilaterally ablated (n=2), however, no deficits in biosonar behavior were observed. Overall, these results indicate that the AC, particularly the DSCF area, plays an important role in the fine-tuning of DSC. They further suggest that all of these behavioral adjustments are predominantly under subcortical control. The role of the Cg in biosonar behavior is unclear, although we hypothesize that it may be involved in enabling the bat to selectively attend to its own pulses, and their resulting echoes, in an acoustically cluttered environment.

Our second behavioral task is a conditioned shock avoidance discrimination task using a leg flexion response. It is designed to probe more directly perceptual deficits caused by AC lesions. Bats are taught to discriminate between two trains of pulse+echo pairs. In our first experiment, bats (n=3) have learned to discriminate between a train of 61.0 kHz pulses + 61.0 kHz echoes, and a train of 61.0 kHz pulses and echoes which jitter between 61.0 kHz and 61.1 kHz (i.e. a frequency change of < 0.2%). This month we will be performing reversible lesions of the AC on these bats using muscimol.

Plans for the coming year involve extending the leg flexion task to examine the role of the various AC subdivisions in discriminations of other acoustic parameters (echo delay, intensity, frequency and amplitude modulation). For example, a given bat will be trained on two discriminations, one involving frequency differences and a second involving differences in echo delay. Lesioning of its DSCF area (and/or its CF/CF area) should disrupt only the frequency discrimination, whereas lesioning of the FM-FM area should disrupt only the range discrimination. Also, the pendulum task will be used to explore the role of subcortical structures and the Cg in biosonar behavior. We will further examine the importance of the AC for sound localization in the azimuthal plane by measuring head and pinnae movements to synthetic biosonar pulses played over loudspeakers positioned on a semicircular hoop in front of the bat. Rather than employing the aspiration lesions used during our first year of research, we will apply muscimol to create reversible lesions.

Publications Resulting from Grant

Gaioni, S.J., Suga, N., & Riquimaroux, H. Effects of bilateral ablations of the auditory and/or cingulate cortices on the biosonar behavior of the mustached bat. To be submitted to Journal of Neurophysiology.

Riquimaroux, H., Gaioni, S.J., & Suga, N. Frequency discrimination in the mustached bat using conditioned leg flexion. To be submitted to Hearing Research.

Papers Presented at Meetings

Gaioni, S.J., Suga, N., & Riquimaroux, H. Biosonar behavior of mustached bats (Pteronotus parnellii) swung on a pendulum. Animal Behavior Society Meeting, Missoula Montana, 1988.

Gaioni, S.J., Suga, N., & Riquimaroux, H. Effects of bilateral ablation of the auditory cortex and/or cingulate cortex on the biosonar behavior of the mustached bat. Society for Neuroscience 18th Annual Meeting, Toronto, 1988.

Riquimaroux, H., Gaioni, S.J., & Suga, N. Effects of bilateral ablation of auditory and/or cingulate cortices on bat echolocation behavior. To be presented at the Association for Research in Otolaryngology Midwinter Meeting, Clearwater Florida, 1988.

Participating Professionals

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